ONTARIO WATER RESOURCES COMMISSION

REPORT

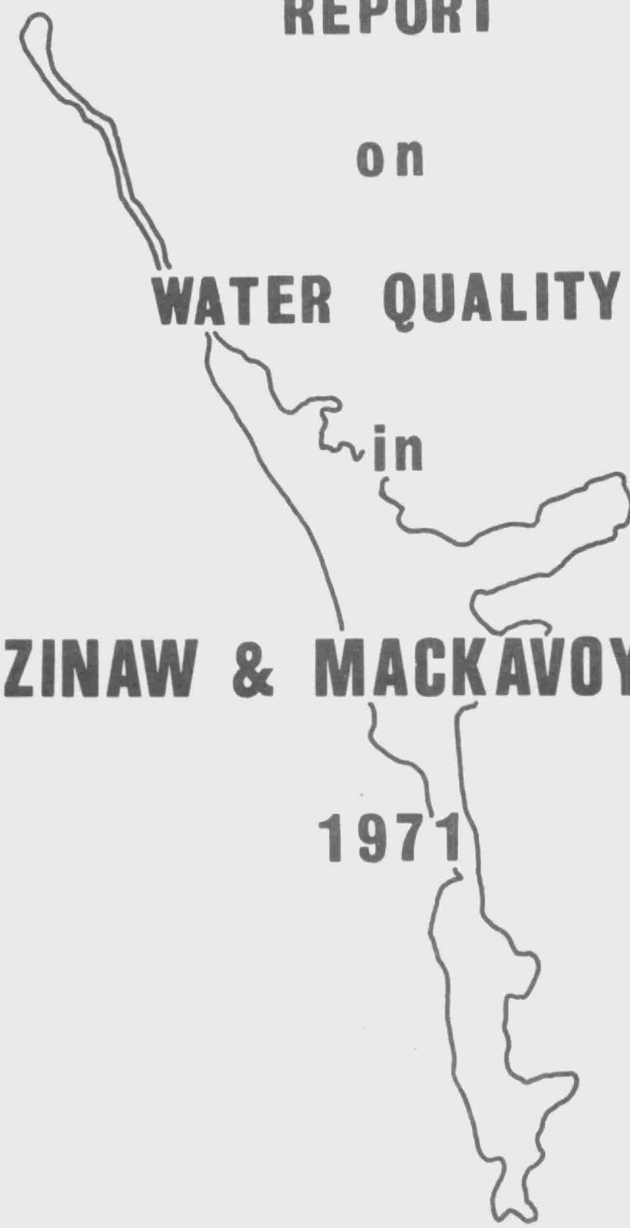
on

WATER QUALITY

in

MAZINAW & MACKAVOY LAKES

1971



RECREATIONAL LAKES PROGRAM

THE

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SUMMARY

A study to evaluate the status of water quality in Mackavoy and Mazinaw lakes was carried out during the summer of 1971.

Mackavoy and Mazinaw lakes both lie in the Precambrian Shield north of the Frontenac Axis, and are surrounded by rolling hills, with poor local drainage and shallow overburden covering bedrock. The shoreline is covered with thin layers of a variety of top soils ranging from fine sandy to coarse gravelly loams mixed with black muck in the lower plains. Rock outcrop dominates most of the shoreline. Both the nature of the soils and topography surrounding these lakes can be considered as unsuitable for cottage development utilizing standard subsurface septic tank disposal systems.

Thermal stratification was observed in Mackavoy and Mazinaw lakes during the summer. Oxygen concentrations in the bottom waters of Mackavoy Lake decreased between the July and August surveys. Free carbon dioxide concentrations were higher in the bottom waters than in the surface waters of both lakes.

The chemical water quality was characteristic of soft water Precambrian lakes unaffected by waste inputs. The use of detergents containing phosphates is not necessary in such soft water and should be avoided by area residents.

Chlorophyll _a_ concentrations were very low indicating that the lakes were oligotrophic in character. A sediment diatom analysis on both basins of Mazinaw Lake confirmed the extreme oligotrophic status of that lake.

Both lakes were well within the OWRC bacteriological criteria for total body contact recreational use. Mazinaw Lake had excellent bacteriological water quality during both the July and August surveys. Mackavoy Lake had generally good water quality, however, excessive bacterial contamination was carried into the lake by runoff following the heavy rainfall during the July survey, creating a short term potential health hazard.

Although no surface water is considered potable without prior treatment, disinfection is considered mandatory if the surface water in Mackavoy Lake is used for human consumption.

In order to maintain the existing quality of the water, every effort should be made to ensure that direct flow or leachate from domestic waste disposal systems or other potential sources of pollution do not gain access to the lakes.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Water Resources Commission, the Ontario Department of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Department of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission would evaluate the existing water quality of the respective lakes.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed problems which have come into prominence in recent years are caused by plant nutrients being added to the lake. Excessive algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In line with its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Mackavoy and Mazinaw lakes in the summer of 1971. Two sampling surveys were conducted on Mackavoy and Mazinaw lakes; in early summer from July 2 to 6 and in late summer from August 20 to 24. A third survey was conducted on Mazinaw Lake in the fall from September 29 to October 1. The scope of the first two surveys included the assessment of bacteriological, physical, chemical and biological conditions whereas the third survey was limited to physical, chemical and biological assessment.

Sampling surveys were conducted on an intensive basis (sampling each day for a minimum of five days) which is mandatory for an accurate assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

AREA DESCRIPTION

Geography and Topography

Mackavoy Lake is located in Effingham Township, County of Lennox and Addington and is approximately 4 miles upstream from Mazinaw Lake.

Mazinaw Lake is located in Abinger and Barrie Townships, Counties of Lennox and Addington and Frontenac respectively, and is approximately 50 miles north of Napanee.

Both lakes lie in the Precambrian Shield north of the Frontenac Axis and are surrounded by rolling hills with poor local drainage and shallow overburden covering Precambrian bedrock. In most instances, the soil cover is less than the 5 feet required by the Department of the Environment for the installation of a septic tank system.

The type of soil surrounding Mackavoy Lake belongs to the Monteagle series which is comprised of sandy loam, muck or peat and rock outcrop. The eastern shore of Mazinaw Lake has soil of this series with the exception of the north-eastern tip which belongs to the Wendigo series (loamy sand). The western shore of Mazinaw Lake has soil of the St. Peters' series (gravelly sand loam). Generally the shorelines of both lakes are steep sloping, backed by rolling terrain with a mixed forest consisting of birch, poplar, hemlock, white and red pine, white spruce and white cedar.

Mackavoy Lake lies in a flooded valley of the Mississippi River and runs in a north-south direction. The lake is roughly triangular in shape and is approximately 1200 feet wide at the north end and narrows to 225 feet at its southern limits. It is approximately one mile long and has a water surface area of 65 acres and a shoreline length of 1.8 miles. The maximum depth recorded this summer was 65 feet.

Mazinaw Lake runs in a northwest-southeast direction with a length of approximately 8.5 miles, an average width of 0.75 miles, a water surface area of 3,930 acres, and a shoreline length of 32 miles. The maximum recorded depth of the lake is 475 feet with the greater portion of the lake being more than 100 feet deep.

The aquatic vegetation of both lakes is quite sparse with the exception of the areas by the inlets.

Climate Range

The Mackavoy-Mazinaw lakes area has a mean temperature range of 67° to 69°F in July and 14° to 16°F in January. The annual precipitation is in the range of 32 to 34 inches including 80 inches of snow. According to meteorological reports the area enjoys about 250 days of no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

Mackavoy and Mazinaw lakes, with a combined drainage basin area of 140 square miles, form the headwaters of the Mississippi River and are in the Ottawa River Terminal Drainage Basin. The Mississippi contributes approximately 2% of the Ottawa River's mean annual flow. Water movement is generally from north to south with water rising in the highlands southwest of Denbigh at an elevation of 1300 feet above mean sea level (m.s.l.) and flowing via small lakes and streams to Mackavoy Lake then via the Mississippi River to Mazinaw Lake at an elevation of 875 feet above m.s.l.

Mackavoy Lake's only inlet which enters at the north end of the lake drains Garner, Mouse and Irvine lakes; Bear and Upper Bear ponds; Kilpecker, Vantassel and Louse creeks. The Mississippi River begins as an outlet at the south end of the lake. Between Mackavoy

and Mazinaw lakes the Mississippi River flows sluggishly through a grass covered valley. In this section, four tributaries join the river before it empties into Mazinaw Lake becoming its major inlet. These tributaries are:

1. Stoll Creek which drains Stoll, Feeny and Machesney lakes;
2. Mallory Creek which drains Mallory Lake;
3. Rock Lake Creek which drains Rock Lake;
4. Valhalla Creek which drains Valhalla Lake.

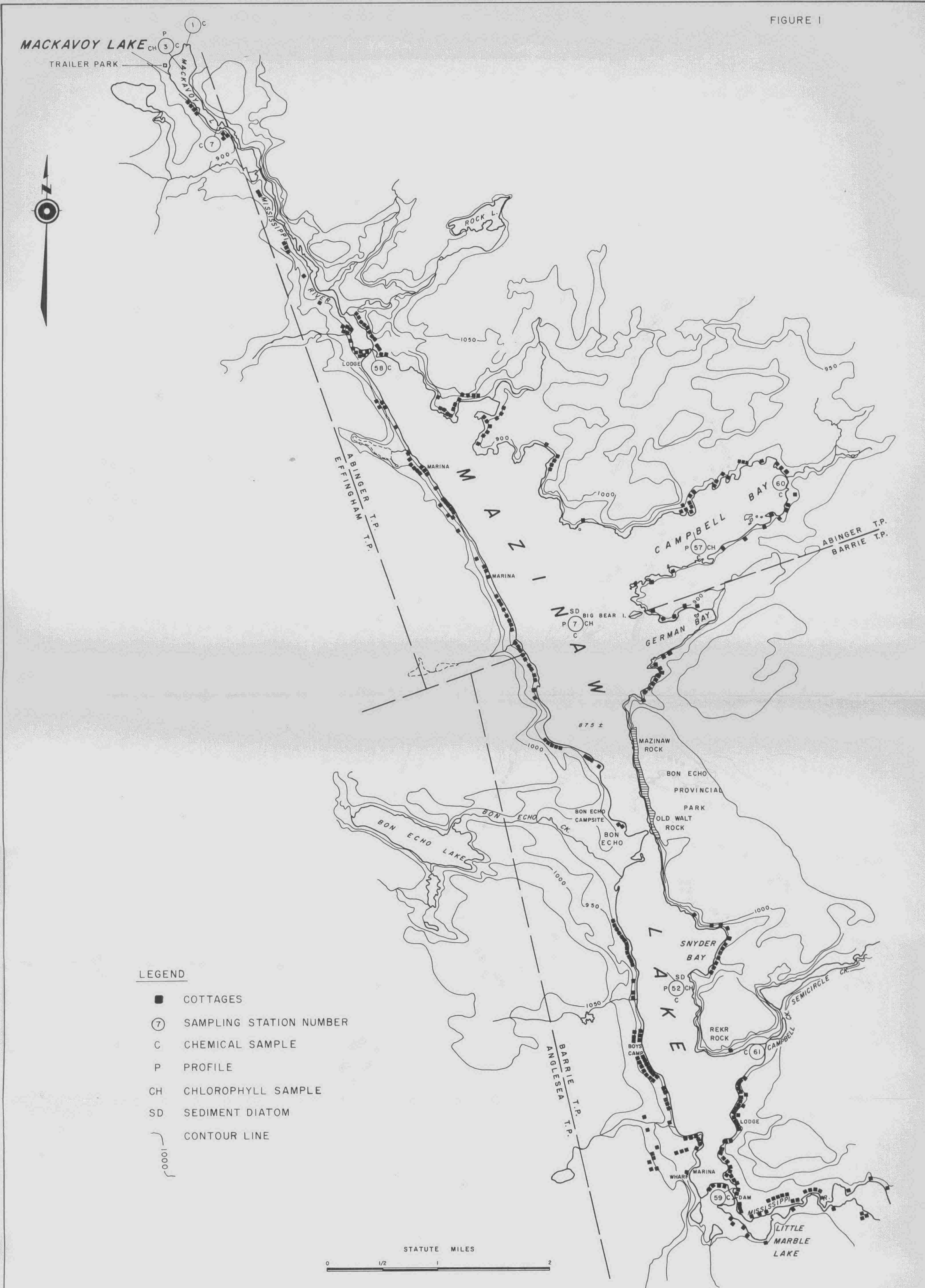
Mazinaw Lake is fed by three other watercourses, before flowing over a control dam at its south end into Little Marble Lake. These are:

1. Campbell Creek which drains Semicircle, Shabomeka, Kishebus, Campbell and Mitchell lakes;
2. Bon Echo Creek which drains Bon Echo, Essens, Abes, Little Long and Little Rock lakes;
3. Tonawa Creek which drains Tonawa Lake.

Shoreline Development

At the present time Mackavoy Lake has seven cottages on its west shore, and one privately operated trailer park with a public bathing beach at its north end. The east shore of the lake remains undeveloped, as a result of its rough and rocky terrain and inaccessibility by road (Figure 1).

Mazinaw Lake has a well developed west shore due to fairly good terrain and road access via Highway 41. Bon Echo Provincial Park is located on the west shore at the narrows which divide the lake into two basins. The park has 250 campsites and 150 trailer sites. The east shore has isolated pockets of development most of which are only accessible by boat. Only the south end of the east shore has road access via the Mazinaw Inn Road. There are two lodges on the lake, one on the north shore and the other on the south-east shore. Both lodges have sandy bathing beaches.



ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

MAZINAW AND MACKAVOY LAKES

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN	
DRAWN BY: R.S.	DATE: FEBUARY 1972
CHECKED BY: A.M.	DRAWING Nº: 72-19-D.E.B

There are three marinas on the west shore of the lake. The map shows the location of the approximately 300 well-spaced cottages (Figure 1).

Water Usage

At the turn of the 20th century the lakes were used for logging operations and to power a grist mill at the south end of Mazinaw Lake. Now the lakes are used entirely for recreational purposes such as boating, swimming and angling. Most of the cottagers also use the lake as their source of domestic water supply.

There is a great variety of fish in the lakes with lake trout, northern pike, walleye, smallmouth and largemouth bass being the prevalent game fish. Twelve other species of common and coarse fish varying from perch to the american eel are also present.

Waste and Refuse Disposal

A township dump located 100 yards west of old Highway 41 at the Massonga Road, serves the area residents and commercial establishments. The dump is in a depression approximately 200 yards north of Stoll Creek, and is operated as a sanitary landfill. To date there are no reports of pollution problems associated with this site.

Bon Echo Provincial Park provides pump-out services for trailers equipped with sewage holding tanks. The wastes are disposed of in a septic tank system, which has been constructed in accordance with, and approved by the local health authority. There are no effluent producing communal or municipal sewage treatment facilities located in the watershed of these lakes.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Physical, chemical and biological water quality surveys were conducted on Mazinaw Lake from July 2 to 6, from August 20 to 24 and from September 29 to October 1. Only the first two surveys were completed on Mackavoy Lake. Six near-shore stations (1 and 7 in Mackavoy and 58, 59 60 and 61 in Mazinaw) as well as four mid-lake stations (station 3 in Mackavoy and 7, 52 and 57) in Mazinaw were selected for physical, chemical and biological sampling. The near-shore stations were close to inlets and outlets.

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily chlorophyll samples were collected in a 32-ounce bottle, at each station, utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10-15 drops of 2% $MgCO_3$.

Once per survey a 32 ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at all stations as well as at the major inlets and outlets. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler.

At each mid-lake station one sample for total phosphorus, total Kjeldahl nitrogen and iron was obtained by means of a Kemmerer sampler from a depth of 1 meter above the bottom on August 20. Three sediment cores for diatom frustule examination were collected during the late autumn at stations 7 and 52 on Mazinaw. From the surface of each sediment core three sub samples were removed for laboratory ennumeration to species.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths 600 to 750 mμ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll *a* were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Five day intensive bacteriological surveys were completed on the Mackavoy and Mazinaw lakes during the July and August surveys. Each day 63 stations were sampled at a depth of 1 meter below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Additional samples were collected in Mazinaw Lake at stations 7, 10, 15, 23, 48 and 52 (Figure 6) one meter above the bottom using a modified "piggy-back" sampler and sterile 237 ml evacuated rubber air syringes. All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms, and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. These "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do no multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin. All the bacteriological data collected in these surveys has been summarized by statistical methods to form a concise outline of the bacterial concentrations.

Bacteriological Statistical Methods

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done

using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analyses of variance program (ANOVA-CRE; Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed. Since the Bartlett's test was found to be significant, in Mazinaw Lake during the August survey station 2 which possessed a significantly higher variance was removed from that group, then the analysis of variance (F-test; Sokal, 1969) was calculated for all the stations. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the June survey to that from the July survey.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

Mackavoy Lake

In July and August, a well-defined thermocline was apparent between 3 and 6m (Figures 2a and 2b). Hypolimnetic temperatures were 5.5^{o}C warmer in August than in July. Significant dissolved oxygen decreases were detected through the metalimnion during both surveys. The hypolimnetic oxygen deficits resulted from bacterial oxidation of organic material, biological respiration and chemical oxidation of organic matter.

Mazinaw Lake

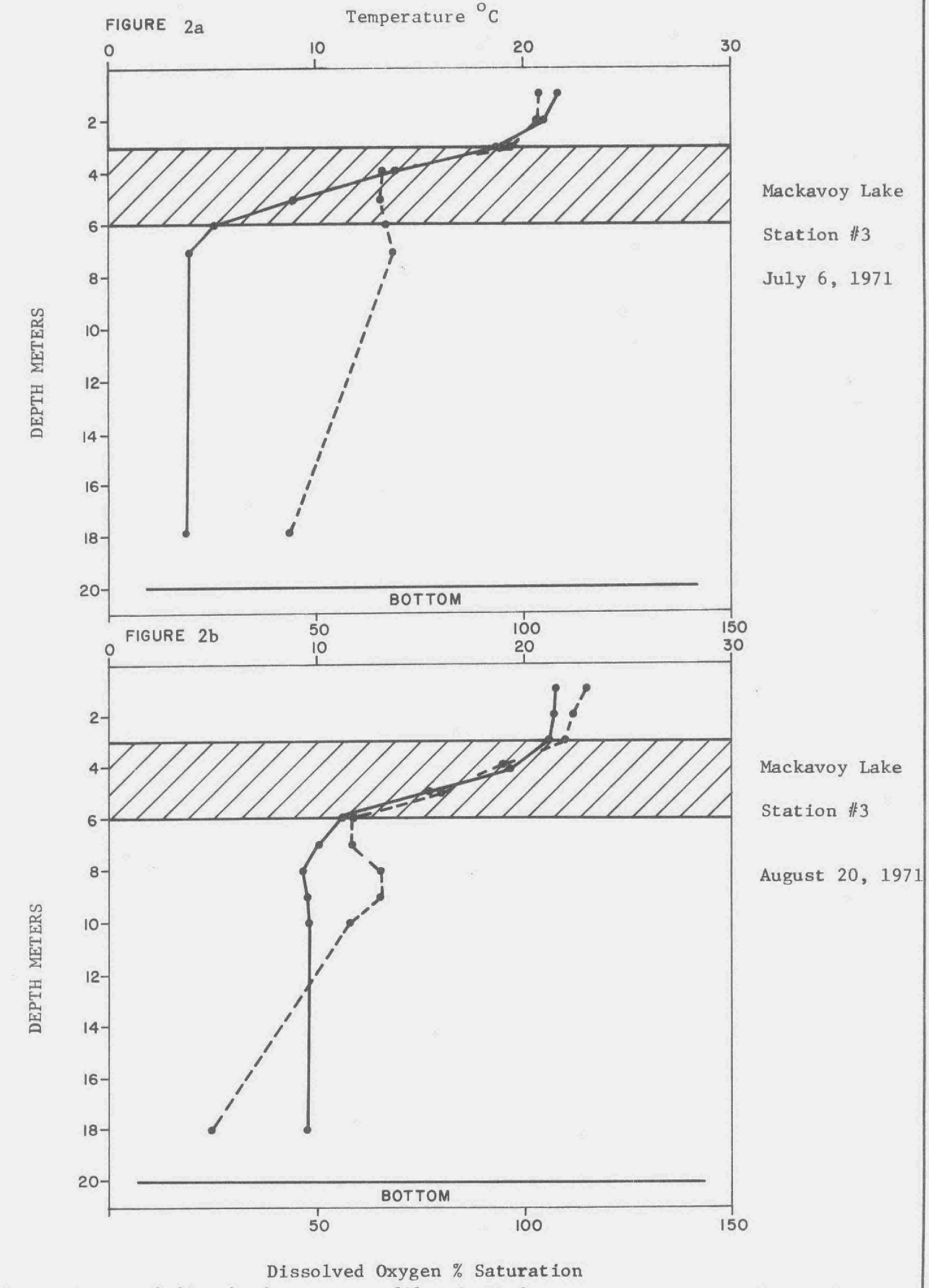
During the July survey, a well defined thermocline characterized by a temperature change of 10.6^{o}C between 5 and 10m was apparent (Figure 3). There was a slight oxygen reduction through the metalimnion while oxygen depletion below 10m was not apparent.

In August the thermocline was lower than in July, being located between 7 and 12m (Figure 4a). This phenomenon was in keeping with the expected seasonal change and is characteristic of small inland lakes. Supersaturated oxygen concentrations were evident in both the epilimnion and hypolimnion.

In October, the thermocline was one m thinner than in August being located between 10 and 14m (Figure 4b). The reduction in thickness of the thermocline and in the epilmnetic temperature was predominately the result of the onset of cool autumn air temperatures and windy weather. Dissolved oxygen concentrations were uniform within the epilimnion and hypolimnion while a definite decrease was apparent in the upper portion of the metalimnion.

pH, Alkalinity and Free Carbon Dioxide

In Mackavoy and Mazinaw lakes, surface pH values were near neutral. The pH was generally higher in the surface waters than in the deeper strata. For example, on July 2, in Mackavoy Lake,



Temperature and dissolved oxygen profiles in Mackavoy Lake, (a) station #3 for July 6, 1971 and (b) station #3 for August 20, 1971. The shaded areas approximate the position of the thermocline.

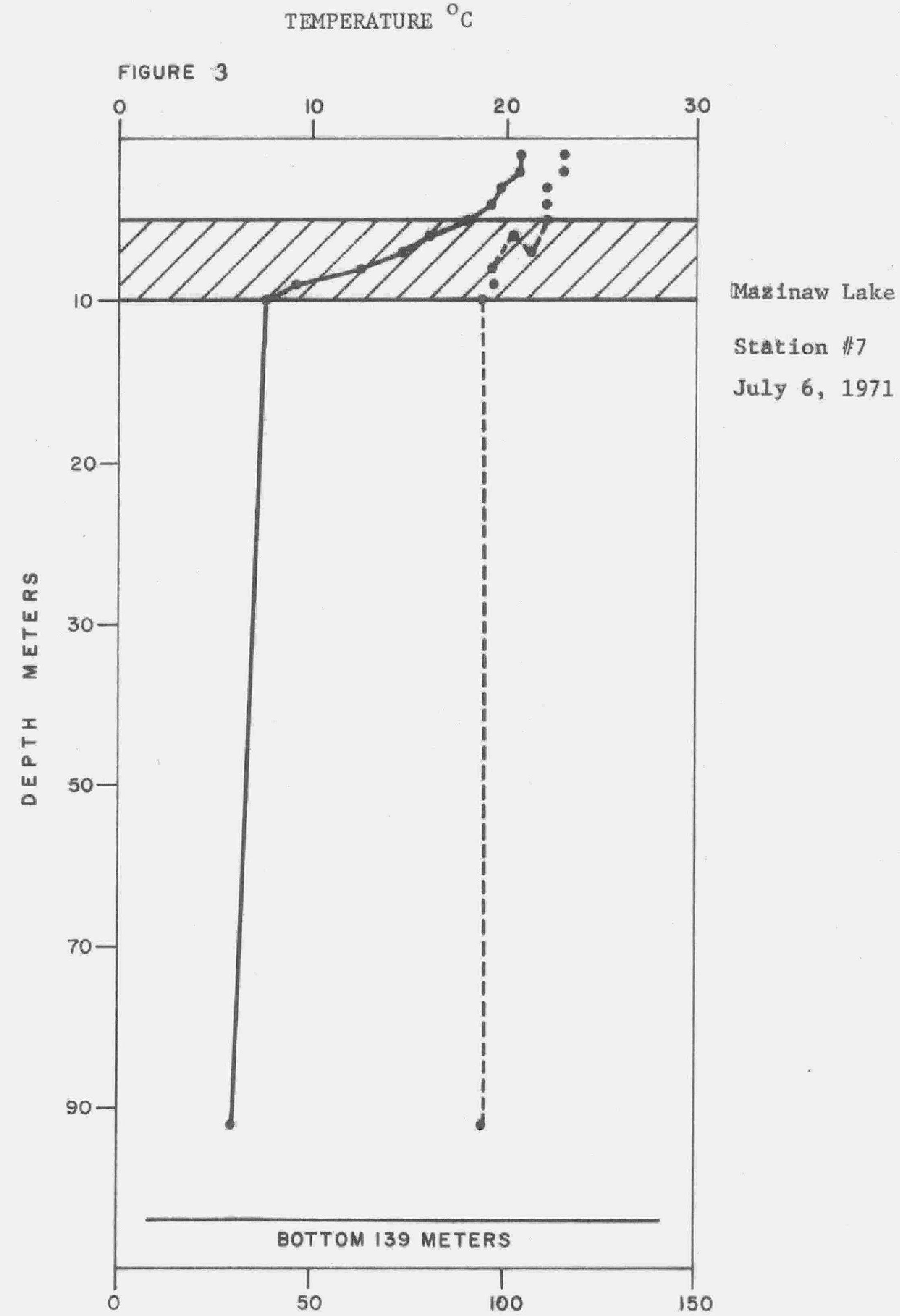


Figure 3

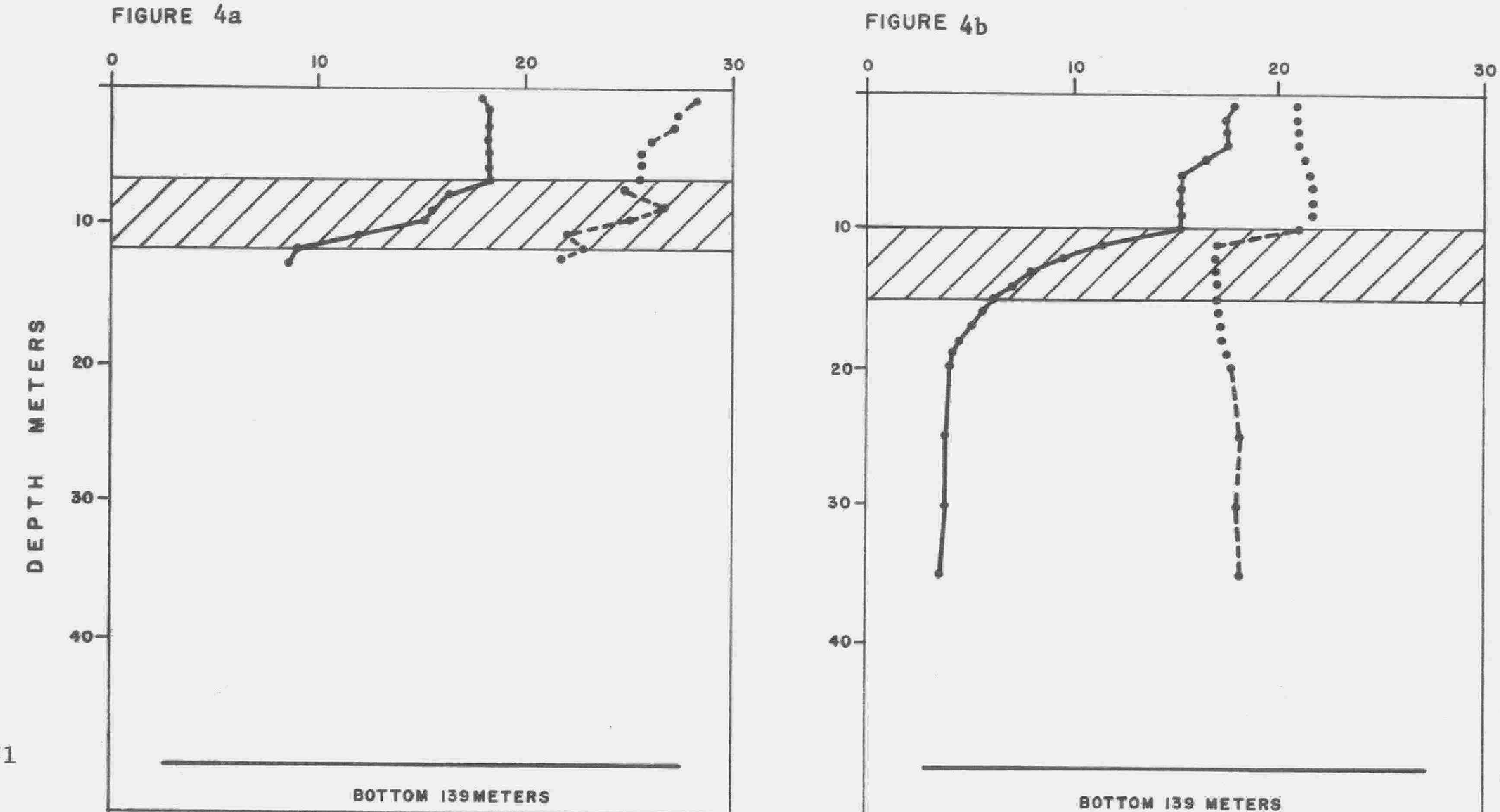
Temperature and dissolved oxygen profiles in Mazinaw Lake, station #7, July 6, 1971

____________ Temperature

\- - - - - - - - - Dissolved Oxygen

Figure 4

Temperature ° Centrigrade



Mazinaw
Stn. #7
Aug. 23/71

Mazinaw
Stn. #7
Oct. 1/71

Dissolved Oxygen % Saturation

Temperature and dissolved oxygen profiles in Mazinaw Lake,
(a) station 7 for Aug. 23, 1971 and (b) station 7 for Oct. 1, 1971.
The shaded areas approximate the postion of the thermocline.

______ Temperature

-------Dissolved Oxygen

values at 1 and 20m were 7.5 and 6.8 respectively, while Mazinaw Lake values at 1 and 19m were 7.2 and 6.8 respectively. Free carbon dioxide concentrations were generally higher in the bottom waters than in the epilimnion of both lakes. Specifically, on October 1, values at 1 and 19m on Mazinaw Lake were 4.2 and 10.9 mg/l respectively, while Mackavoy Lake concentrations at 1 and 20m were 5.6 and 12.4 mg/l on August 22.

Total alkalinity values in the surface waters (47.6 mg/l) of Mackavoy Lake were considerably higher than the bottom waters (23.1 mg/l), during both surveys. This resulted from the hard water input from the northern inlet which accumulated in the epilmnion after the formation of the thermocline.

In Mazinaw Lake total alkalinity values were generally higher in the surface water than in the bottom waters. This may have resulted from Mackavoy Lake water entering the epilimnion of Mazinaw lake via the Mississippi River.

Hardness, Conductivity, Chloride and Iron

Hardness values in Mackavoy Lake ranged from 42 to 66 mg/l and the concentrations near the inlet and outlet were consistently higher than the center of the lake.

For all three surveys in Mazinaw Lake the hardness values ranged from 30 to 40 mg/l with one exception. Station 58 near the inlet from Mackavoy Lake was sampled in July and had a hardness of 50 mg/l which was consistent with the outlet values for Mackavoy Lake.

Soaps will be effective in such soft waters, therefore, the use of detergents containing phosphorus is unnecessary.

Conductivity values for both lakes ranged from 70 to 137 umhos/cm^3 and were always consistent with hardness, alkalinity and chloride concentrations, indicating that no unusual mineral characteristics were present.

The chloride concentrations for both lakes generally ranged from 1 to 4 mg/l which is normal for soft water lakes. In July, a concentration of 7 mg/l was observed near an inlet to Mackavoy (station 1) and a concentration of 8 mg/l was observed near an inlet to Mazinaw Lake (station 58). While these results were slightly higher than usual and could be due to effects of road salting, the concentrations were neither of a sufficient magnitude nor of a sufficiently consistent pattern to allow conclusions to be drawn.

The surface iron concentrations ranged from 0.05 to 0.20 mg/l in both lakes with one exception, station 61 near the inlet from Lake Shabomeka contained 0.65 mg/l of total iron on July 6.

Kjeldahl Nitrogen and Total Phosphorus

The surface concentrations of Kjeldahl nitrogen in Mackavoy Lake for both surveys ranged from 0.19 to 0.35 mg/l and the total phosphorus concentration ranged from 0.003 to 0.012 mg/l.

In Mazinaw Lake the surface concentrations of Kjeldahl nitrogen and total phosphorus for all three surveys ranged from 0.21 to 0.33 mg/l and from 0.002 to 0.016 mg/l respectively. There were no apparent trends in concentration between surveys in either lake.

The low nitrogen and phosphorus concentrations would not be expected to support nuisance levels of algae and since major inlet stations were included, therefore, it would appear that there were no sources of nutrient enrichment during the surveys.

The nitrogen:phosphorus weight ratios averaged 41 for both lakes which is indicative of natural waters unaffected by waste inputs (Edmondson 1970).

Depth samples from station 3 (18m) on Mackavoy Lake, and from stations 7 (125m), 52 (54m) and 57 (10m) on Mazinaw Lake had Kjeldahl nitrogen concentrations from 0.26 to 0.42 mg/l and total phosphorus from 0.006 to 0.036 mg/l. These are low values for hypolimnetic samples and indicated that recycling of nitrogen and phosphorus from the sediments was not occurring.

Chlorophyll a

In Mazinaw Lake, chlorophyll a concentrations were extremely low at all three stations ranging from 0.6 to 1.3 ug/l, 0.6 to 1.9 ug/l and 0.4 to 0.8 ug/l for the July, August and September surveys respectively (Table 1). Mackavoy Lake possessed chlorophyll a concentrations ranging from 0.6 to 1.3 ug/l and 0.8 to 1.3 ug/l during the July and August surveys. These values are indicative of extremely low algal populations.

Water clarity, which is one of the more important parameters used in defining water quality, can be measured using a Secchi disc. Figure 5 presents a chlorophyll a - Secchi disc relationship for a number of surface waters in Ontario and clarifies the "trophic status" of Mazinaw and Mackavoy lakes in relation to numerous other well known recreational lakes in the Province (see Brown 1972 for derivation of chlorophyll a - Secchi disc relationships). With respect to Figure 5, all stations on Mazinaw Lake were positioned in close proximity to values computed for oligotrphic Lake Superior and were well removed from Gravenhurst Bay, Riley Lake, the Western Basin of Lake Erie and the Bay of Quinte, four extremely enriched bodies of water. Mackavoy Lake was positioned midway between the oligotrophic lakes, Superior and Huron and the more mesotrophic Lake Ontario and Eastern Basin of Lake Erie.

FIGURE 5

CHLOROPHYLL a - SECCHI DISC RELATIONSHIP

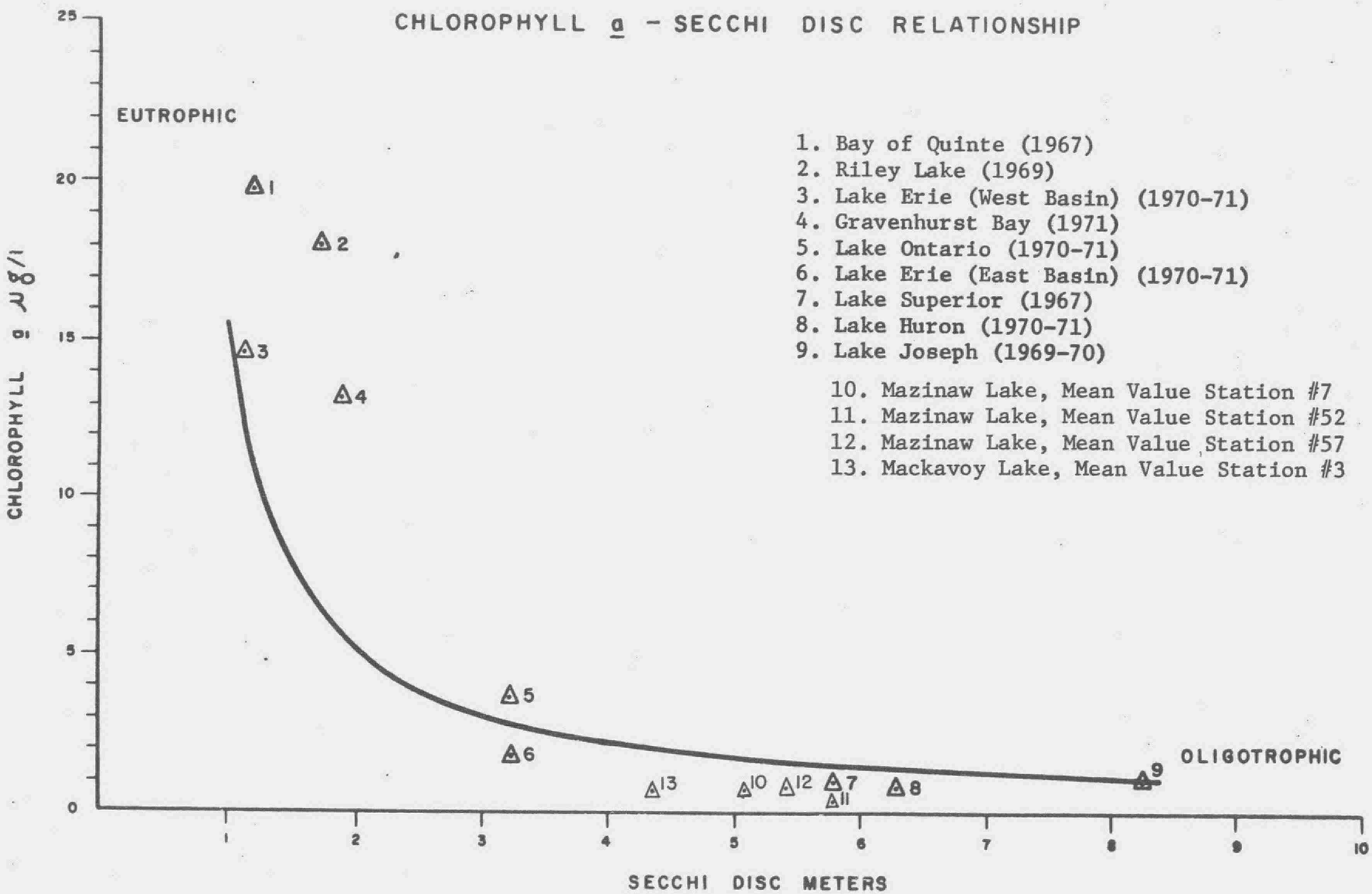


Figure 5

The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the mean chlorophyll a and Secchi disc values for stations 7, 52 and 57 on Mazinaw Lake and station 3 on Mackavoy Lake.

Sediment Diatom Analyses

A good deal may be learned about the developmental history of a lake by studying the distribution and succession of diatoms in lake sediments. The frustules are well preserved under most limnological conditions and due to their specific gravity, sink to the bottom and remain in the sediments. Therefore, the sediment sample extracted from the upper one centimeter of the core sample contains diatoms representative of the recent trophic status of a lake.

Using a ratio of diatom groups, Araphidinae to Centrales (A/C) in lake sediments, Stockner 1971, developed a technique which classifies the trophic status in a number of soft water lakes in north-west Ontario and developed the following broad trophic distinctions for lakes:

Type	Ratio
Oligotrophic	0-1.0
Mesotrophic	1.0-2.0
Eutrophic	2.0

To classify Mazinaw Lake, triplicate analyses on three sediment cores collected from both stations 7 and 52 were quantitatively and qualitatively examined. The enumeration revealed mean A/C ratios of 0.137, 0.117 and 0.127 for station 7 and 0.137, 0.137 and 0.140 for station 58. The values indicate that both basins of Mazinaw Lake contain planktonic diatom populations characteristic of extremely oligotrophic lakes.

Bacteriology

In general, Mazinaw and Mackavoy lakes were well within the OWRC criteria for total body contact and recreational use (OWRC, 1970) during both the July and August surveys, although the water quality of Mackavoy Lake was not as good. The lakes were divided into four major groups during the July and August surveys on the basis of bacterial concentrations (Figures 6 & 7). The summaries of the analysis of variance used to determine these groups are presented in tables 3, 4 & 5.

Mackavoy Lake

Mackavoy Lake, in the July survey, was homogeneous and within the OWRC criteria, with overall geometric means of 129 TC/100 ml, 6 FD/100 ml and 10 FS/100 ml. In the August survey these means dropped to 24 TC/100 ml, 1 FC/100 ml and 7 FS/100 ml. The higher geometric means in July have been attributed largely to the intensive recreational use of the lake during the July 1 to 4 holiday weekend, coupled with a fairly heavy rainfall on July 5 (0.65 inches were recorded at the climatological station at Cloyne) and a light rain on the evening of July 1. The flushing action of the rain carried large numbers of bacteria into the lake which caused an increase in TC, FC and FS concentrations on July 3 and a sharp increase on July 6, to the extent that all TC counts exceeded 1000/100 ml, but the geometric mean taken over the five day sample period leveled out these peak counts.

Individual station geometric means for FS showed that station 2 (30 FS/100ml) and station 7 (21 FS/100 ml) exceeded the OWRC criteria for recreational use, but were not significantly higher than the rest of Mackavoy Lake and fell within the overall geometric mean of 10 FS/100 ml. The rainfall on July 5 caused the excessively high FS counts at stations 2 and 7.

The August survey showed a significant drop in TC (student t-test, t = 3.71; degrees of freedom, df = 67) and FC (t = 5.54, df = 61) concentrations from July survey in spite of the 0.56 inches of rainfall on August 22. However, the weather had been dry and hot prior to the rain which likely reduced the amount of runoff.

Mazinaw Lake

The bacteriological water quality of Mazinaw Lake was generally better than Mackavoy Lake during both the July and August surveys (Table 6), mainly because Mazinaw Lake did not show a significant increase in bacterial levels after the rain.

Mazinaw Lake was divided into three major groups based on bacterial concentrations. These groups remained essentially the same for both the July and August surveys: south of the narrows at Bon Echo Park (Group C in July and Group H in August), north of the narrows (Group B in July and Group F in August), and the depth stations (Group D in July and Group G in August). Group D included station D48 which was geographically isolated but fell within the overall mean for that group ($t = 0.46$, $df = 21$) and Group G included surface station 7 (Figures 6 and 7).

The bacterial concentrations were higher in July than in August (Table 7). These higher counts were attributed largely to the heavy recreational use during the holiday weekend and to the rainfall on July 5.

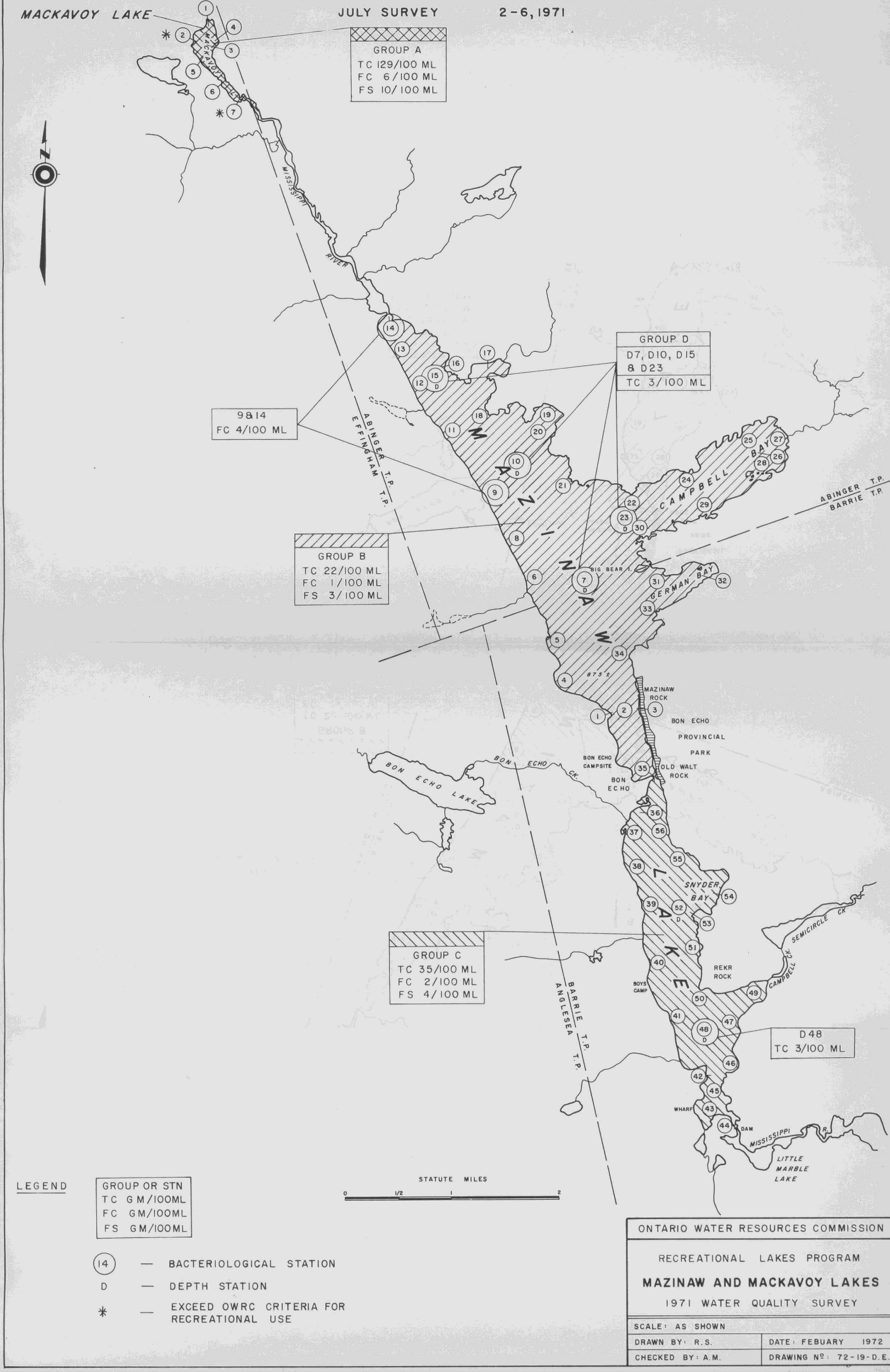
In July, the southern half of Mazinaw Lake (Group C) had significantly higher TC counts ($t = 3.756$, $df = 280$) and FC counts ($t = 3.710$, $df = 293$) than the northern half (Group B, Figure 6). Group D and station D48 had TC levels lower than groups B and C. Stations 9 and 14 both had slight but statistically higher FC counts of 4/100 ml. Station 14 was located near the mouth of the Mississippi River which flowed past cottages, a trailer camp and a lodge. Station 9 was influenced by flow from two storm culverts, which pass under the highway to enter the lake at that point.

During the July survey, some trends in bacterial levels were present in the statistically homogeneous groups. Station 44 (91 TC/100 ml) at the main outlet was probably affected by the dense cottage development on the south shores of Mazinaw Lake. Station 33 (46 TC/100 ml and 7 FS/100 ml) indicated that a bacterial input was reaching the lake near the mouth of German Bay.

The north and south sections of Mazinaw Lake were not significantly different during the August survey. (TC : t = 1.932, df = 268), but Group G (the depth stations) still had lower TC levels (Figure 7). Station 35 had significantly higher TC counts than Group F, probably due to the recreational activity at Bon Echo Park, and station 38 had slight but statistically higher FC concentrations, probably indicating a slight input from the cottages along that shore.

Although Mazinaw Lake had excellent bacterial water quality for recreational use, no surface water in Ontario is considered potable without prior treatment including disinfection. In Mackavoy Lake, particular attention should be paid to any drinking water drawn from the lake, especially after a rain.

FIGURE 6


JULY SURVEY 2-6, 1971
MACKAVOY LAKE
MACKAVOY L.
GROUP A
TC 129/100 ML
FC 6/100 ML
FS 10/100 ML
MISSISSIPPI RIVER
GROUP D
D7, D10, D15 & D23
TC 3/100 ML
9 & 14
FC 4/100 ML
ABINGER T.P.
EFFINGHAM T.P.
GROUP B
TC 22/100 ML
FC 1/100 ML
FS 3/100 ML
MAZINAW LAKE
CAMPBELL BAY
GERMAN BAY
BIG BEAR I.
ABINGER T.P.
BARRIE T.P.
MAZINAW ROCK
BON ECHO PROVINCIAL PARK
BON ECHO CAMPSITE
OLD WALT ROCK
BON ECHO
BON ECHO LAKE
BON ECHO CK.
SNYDER BAY
GROUP C
TC 35/100 ML
FC 2/100 ML
FS 4/100 ML
REKR ROCK
BOYS CAMP
CAMPBELL CK.
SEMICIRCLE CK.
D48
TC 3/100 ML
BARRIE T.P.
ANGLESEA T.P.
WHARF
DAM
MISSISSIPPI R.
LITTLE MARBLE LAKE
STATUTE MILES
0 1/2 1 2
LEGEND
GROUP OR STN
TC GM/100ML
FC GM/100ML
FS GM/100ML
14 — BACTERIOLOGICAL STATION
D — DEPTH STATION
* — EXCEED OWRC CRITERIA FOR RECREATIONAL USE
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
MAZINAW AND MACKAVOY LAKES
1971 WATER QUALITY SURVEY
SCALE: AS SHOWN
DRAWN BY: R.S.
DATE: FEBUARY 1972
CHECKED BY: A.M.
DRAWING Nº 72-19-D.E.

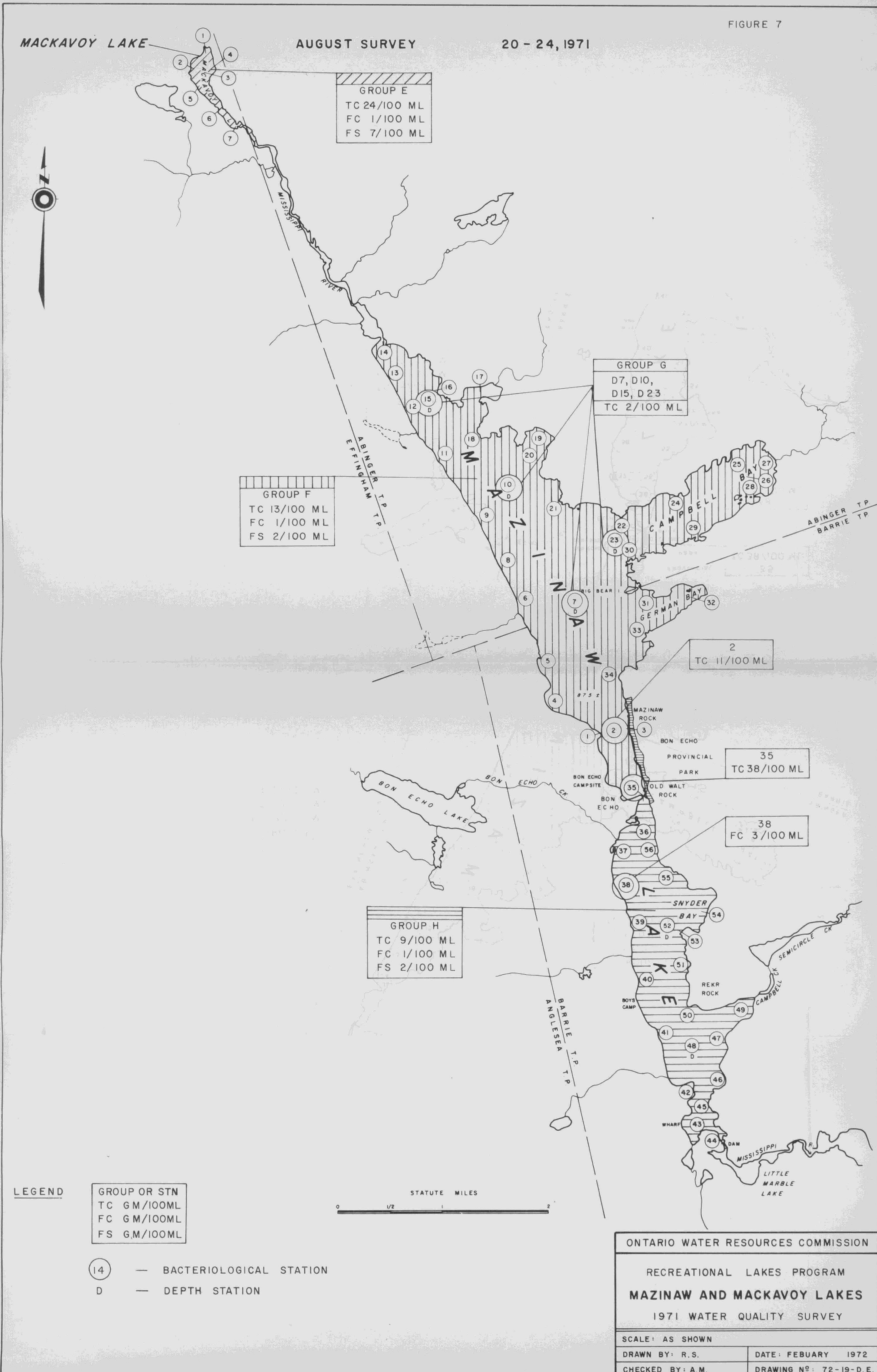


FIGURE 7
MACKAVOY LAKE
AUGUST SURVEY
20 - 24, 1971
GROUP E
TC 24/100 ML
FC 1/100 ML
FS 7/100 ML
MISSISSIPPI RIVER
GROUP G
D7, D10, D15, D23
TC 2/100 ML
GROUP F
TC 13/100 ML
FC 1/100 ML
FS 2/100 ML
ABINGER T.P.
EFFINGHAM T.P.
MAZINAW
CAMPBELL BAY
GERMAN BAY
BIG BEAR I.
ABINGER TP
BARRIE TP
2
TC 11/100 ML
MAZINAW ROCK
BON ECHO PROVINCIAL PARK
35
TC 38/100 ML
BON ECHO CAMPSITE
OLD WALT ROCK
BON ECHO
BON ECHO LAKE
BON ECHO CK
38
FC 3/100 ML
SNYDER BAY
GROUP H
TC 9/100 ML
FC 1/100 ML
FS 2/100 ML
LAKE
REKR ROCK
BOYS CAMP
BARRIE T.P.
ANGLESEA T.P.
SEMICIRCLE CK
CAMPBELL CK
WHARF
DAM
MISSISSIPPI R
LITTLE MARBLE LAKE
LEGEND
GROUP OR STN
TC GM/100ML
FC GM/100ML
FS GM/100ML
14 — BACTERIOLOGICAL STATION
D — DEPTH STATION
STATUTE MILES
0 1/2 1 2
ONTARIO WATER RESOURCES COMMISSION
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DRAWN BY: R.S.
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TABLE 1: Chlorophyll a and Secchi disc values for Mazinaw Lake, stations 7, 52 and 57 as well as Mackavoy Lake station 3.

	Station 7		Station 52		Station 57		Station 3	
	Chlor a	S.D.	Chlor a	S.D.	Chlor a	S.D.	Chlor a	S.D.
July 2	1.2 ug/l	4.0m	- ug/l	- m	1.3 ug/l	4.3m	1.3 ug/l	3.8m
July 3	1.1	4.5	-	-	1.1	5.5	0.9	4.4
July 3	1.1	4.5	-	-	0.6	5.2	-	-
July 4	0.6	4.2	0.6	4.6	0.8	5.2	0.7	4.8
July 5	0.9	3.6	0.6	5.0	0.9	3.9	0.6	4.0
July 6	1.0	5.5	0.8	5.0	1.0	4.3	0.7	4.0
Aug. 20	1.9	4.3	0.8	5.0	1.4	5.0	1.3	5.0
Aug. 21	0.8	7.3	0.6	8.5	0.6	7.3	-	-
Aug. 22	-	-	-	-	-	-	0.8	4.8
Aug. 23	1.0	7.5	0.6	7.5	0.8	7.5	0.8	4.8
Aug. 24	1.0	7.5	0.8	8.0	0.8	7.5	1.2	4.0
Sept.29	0.6	4.5	0.4	4.5	0.7	5.0	-	-
Sept.30	0.4	5.0	0.7	5.0	0.6	5.0	-	-
Oct. 1	0.5	5.0	0.6	5.0	0.8	5.0	-	-
MEAN	0.93	5.18	0.65	5.81	0.88	5.44	0.92	4.40

Chlor a = Chlorophyll a

S.D = Secchi Disc

ug/l = Micrograms per liter

m = Meters

TABLE 2: The Araphidinae/Centrales ratio of the surface sediment samples collected from Mazinaw Lake, stations 7 and 52. The samples were collected in triplicate during the autumn of 1971 and three separate analyses were performed on each core sample.

	CORE 1			CORE 2			CORE 3		
STATION #7	A1	A2	A3	B1	B2	B3	C1	C2	C3
A/C RATIO	0.14	0.13	0.14	0.10	0.13	0.11	0.11	0.17	0.10
MEAN A/C RATIO		0.137			0.117			0.127	
STATION #52									
A/C RATIO	0.17	0.16	0.08	0.12	0.17	0.12	0.11	0.07	0.14
MEAN A/C RATIO		0.137			0.137			0.140	

TABLE 3a: Summary of the Analysis of Variance Grouping of Stations
Mackavoy Lake
Parameter: Total Coliform (TC)/100 ml.

Survey	July 2 to July 6	August 20 to August 30
Group	Group A (all stations)	Group E (all stations)
F	0.041	2.323
df	6 , 27	6 , 28
F (.05)	2.462	2.448
	NSD	NSD
Log GM	2.109	1.388
SE	0.190	0.051
N	34	35
GM	129	24

TABLE 3b: Summary of the Analysis of Variance Grouping of Stations
Mazinaw Lake (Section 1 (stations 1 to 35) with depths at 7,10,15,23)
Parameter: Total Coliform (TC)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	All Stations	All Stations
F	3.047	2.638
df	39 , 155	38 , 156
F (.05)	1.491	1.496
	SD	SD
Group	Group B (all stn's except D7,D10,D15,D23)	Group F (all stn's except 7,D7,D10,D15,D23,35,2)
F	1.234	1.141
df	35 , 141	31 , 128
F (.05)	1.50	1.46
	NSD	NSD
Log GM	1.336	1.050
SE	0.033	0.034
N	177	160
GM	22	13
Group	Group D (D7, D10, D15, D23)	Group G (7, D7, D10, D15, D23)
F	1.379	0.426
df	3, 14	4, 20
F (.05)	3.34	2.86
	NSD	NSD
Log GM	0.399	0.327
SE	0.116	0.096
N	18	25
GM	3	2

TABLE 3c: Summary of the Analysis of Variance Grouping of Stations
Mazinaw Lake - Section 2 (Stn. 36 - 56 with a depth at 48)
Parameter: Total Coliform (TC)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	All Stations	All Stations
F	2.252	0.972
df	21 , 88	21 , 88
F (.05)	1.682	1.682
	SD	NSD
Group	Group C (All stations except D48)	Group H All Stations
F	1.194	0.972
df	20 , 84	21 , 88
F (.05)	1.66	1.682
	NSD	NSD
Log GM	1.543	0.945
SE	0.045	0.043
N	105	110
GM	35	9

TABLE 4a: Summary of the Analysis of Variance Grouping of Stations
Mackavoy Lake
Parameter: Fecal Coliform (FC)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	Group A (all stations)	Group E (all stations)
F	0.166	0.840
df	6 , 22	6 , 28
F (.05)	2.552	2.448
	NSD	NSD
Log GM	0.757	0.043
SE	0.135	0.031
N	29	33
GM	6	11

TABLE 4b: Summary of the Analysis of Variance Grouping of Stations
Mazinaw Lake, Section 1 (1-35 with depths at 7,10,15,23)
Parameter: Fecal Coliform (FC)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	All Stations	All Stations
F	1.494	1.124
df	39 , 155	38 , 156
F (.05)	1.491	1.496
	SD	NSD
Group	Group B (all stations except 9 & 14)	Group F (all stations)
F	0.903	1.124
df	37 , 148	38 , 156
F (.05)	1.491	1.496
	NSD	NSD
Log GM	0.097	0.045
SE	0.020	0.012
N	185	195
GM	1	1

TABLE 4c: Summary of the Analysis of Variance Grouping of Stations
Mazinaw Lake
Section 2 (36-56, with a depth at 48)
Parameter: Fecal Coliform (FC)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	All Stations	All Stations
F	0.765	1.944
df	21 , 88	21 , 88
F (.05)	1.682	1.682
	NSD	SD
Group	Group C (All Stations)	Group H (All Stations Except 38)
F	0.765	1.08
df	21 , 88	20 , 84
F (.05)	1.682	1.66
	NSD	NSD
Log GM	0.240	0.040
SE	0.037	0.015
N	110	105
GM	2	1

TABLE 5a: Summary of the Analysis of Variance Grouping of Stations
Mackavoy Lake
Parameter: Fecal Streptococcus (FS)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	Group A (All Stations)	Group E (All Stations)
F	1.355	1.382
df	6 , 27	6 , 28
F (.05)	2.462	2.448
	NSD	NSD
Log GM	0.978	0.820
SE	0.105	0.070
N	32	33
GM	10	7

TABLE 5b: Summary of the Analysis of Variance Grouping of Stations
Mazinaw Lake - Section 1 (1 - 35 with depths at 7, 10, 15, 23)
Parameter: Fecal Streptococcus (FS)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	Group B (All Stations)	Group F (All Stations)
F	1.315	1.126
df	39 , 155	38 , 156
F (.05)	1.491	1.496
	NSD	NSD
Log GM	0.511	0.283
SE	0.037	0.028
N	195	195
GM	3	2

TABLE 5c: Summary of the Analysis of Variance Grouping of Stations
Mazinaw Lake - Section 2 (36 - 56 with a depth at 48)
Parameter: Fecal Streptococcus (FS)/100 ml.

Survey	July 2 to July 6	August 20 to August 24
Group	Group C (All Stations)	Group H (All Stations)
F	0.761	0.752
df	21 , 87	21 , 24
F (.05)	1.683	1.682
	NSD	NSD
Log GM	0.629	0.363
SE	0.053	0.050
N	109	110
GM	4	2

SUMMARY OF T-TESTS BETWEEN MACKAVOY AND MAZINAW LAKES FOR JULY AND AUGUST

TABLE 6a: Total Coliforms

Mackavoy	Mazinaw Lake July Section 1	Section 2	August Section 1	Section 2
t	6.918	4.850	4.14	5.431
df	209	137	193	143
t (.05)	1.96	1.98	1.96	1.98
	SD**	SD**	SD**	SD**

TABLE 6b: Fecal Coliforms

Mackavoy	Mazinaw Lake July Section 1	Section 2	August Section 1	Section 2
t	9.026	5.189	0.063	0.0941
df	212	137	226	136
t (.05)	1.96	1.98	1.96	1.98
	SD**	SD**	NSD	NSD

TABLE 6c: Fecal Streptococcus

Mackavoy	Mazinaw Lake July Section 1	Section 2	August Section 1	Section 2
t	3.085	4.637	4.612	7.266
df	139	225	141	226
t (.05)	1.98	1.96	1.98	1.96
	SD*	SD**	SD**	SD**

SUMMARY OF T-TESTS FOR THE GROUPS IN MAZINAW LAKE BETWEEN THE JULY AND AUGUST SURVEYS

TABLE 7a: Total Coliforms

August Survey	July Survey: GROUP B	July Survey: GROUP C	July Survey: GROUP D
GROUP F	t = 6.029 df = 335 t(.05) = 1.960 SD**		
GROUP H		t = 9.612 df = 213 t(.05) = 1.960 SD**	
GROUP G			t = .0800 df = 41 t(.05) = 2.021 NSD

TABLE 7b: Fecal Coliforms

August Survey	July Survey: GROUP B	July Survey: GROUP C	July Survey: GROUP D
GROUP F	t = 2.256 df = 378 t(.05) = 1.960 SD		
GROUP H		t = 4.924 df = 213 t(.05) = 1.960 SD**	

TABLE 7c: Fecal Streptococcus

August Survey	July Survey: GROUP B	July Survey: GROUP C	July Survey: GROUP D
GROUP F	t = 4.913 df = 388 t(.05) = 1.960 SD**		
GROUP H		t = 3.651 df = 217 t(.05) = 1.960 SD**	

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where $S.E. = \frac{s}{\sqrt{n}}$ and s = standard deviation
N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydroxide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL <u>a</u>	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram 1.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

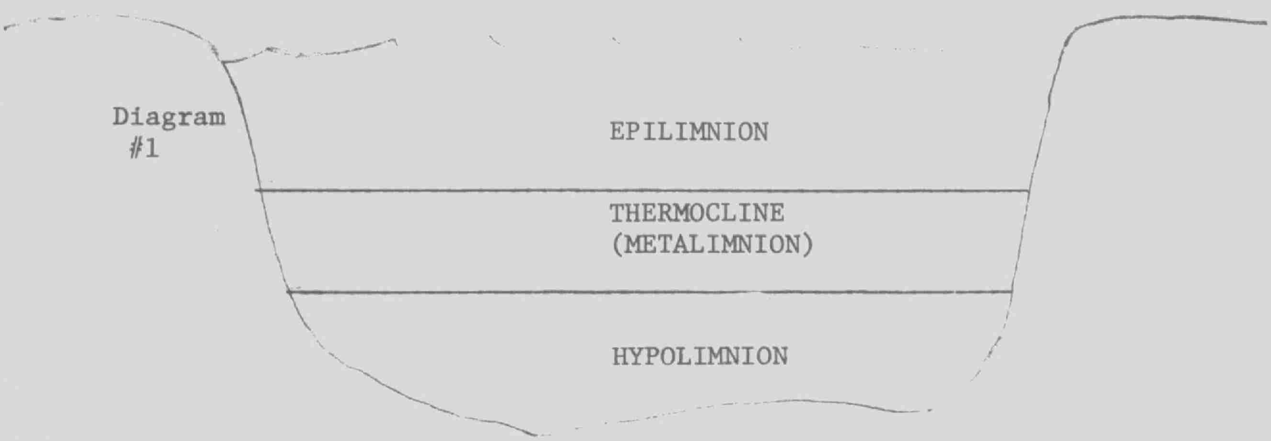
EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent' man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram 1.
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC :A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. See Diagram #1.

THERMOCLINE (METALIMNION):The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding $1^{o}C$ increase per meter.

Diagram #1



TOTAL COLIFORMS (TC) :Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS :Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three integrading types:

TROPHIC STATUS (continued) oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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